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EFFECTS OF DIFFERENT LEVELS OF SOIL MOISTURE AND INDIGENOUS ORGANIC AMENDMENTS ON THE YIELD OF BORO RICE GROWN UNDER FIELD CONDITION

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Key words: Different soil moisture levels, Rice straw compost, Mustard metal, Trichocompost, Growth and yield of rice

Abstract

A field study was conducted to determine the potentials of moist (70% soil moisture) and saturated (> 100% soil moisture) soil conditions and organic amendments of rice straw compost (RSC), mustard meal (MM) and trichocompost (TC) on the selected rice varieties of BR 3, local BRRI dhan 29 and BRRI dhan 74 in relation to the growth and yield attributes of rice varieties. The rates of amendments were 0, 4, 8 t/ha for RSC; 0, 3, 6 t/ha for MM and 0, 2.5, 5 t/ha for TC. The maximum grain yield of 8.71 t/ha was attained from the RSC_4ML_{100} and 8.58 t/ha from RSC_4ML_{70} treatments. The moist condition of soil had almost similar effects on the number of productive tillers, grain yield, number of filled and fissured grains, 1000-grain weight and harvest index as compared to saturated condition along with the doses of RSC, MM and TC. The RSC (4 t/ha) was the superior treatment with respect to the growth and yield components of rice followed by the treatments of TC (2.5 t/ha) and MM (3 t/ha), irrespective of rice varieties and moisture levels.

Introduction

Bangladesh is one of the largest deltas in the world which is largely vulnerable to climate change and global warming because of its geographical location. Changing climatic conditions negatively act upon soil moisture. Near-surface soil moisture is the net result of a suite of complex processes viz. precipitation, evapotranspiration, drainage, overland flow and infiltration, etc. As a result, regional to global-scale simulations of soil moisture and drought remain relatively uncertain(1). The multi-model projections of 21st century showed that annual mean soil moisture changes as decreasing in the subtropical regions. As a consequence, the food security and soil quality are threatened due to inadequacy of soil moisture. Furthermore, inclusive research and adequate measures should be adopted to avoid these hazards.

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Rice cultivation in Bangladesh, especially boro rice completely depends on irrigation water(2). Irrigated rice can produce higher yield but with high water input since it is grown in puddled field that requires continuous flooding(3). Generally, 3000 to 5000 L water is needed to produce 1 kg rice(4). Limited water availability in the future coupled with climate change effects may reduce the capacity of farmers to irrigate their fields, which may result in increased incidence to crop water stress(5). The understanding of physiological and morphological adaptations of rice varieties to water stress at selected growth stages is crucial in minimizing water uses, future improvement of water use efficiency and maximizing rice productivity. Physiological potentiality of moisture stress tolerance of different rice varieties needs to be studied so that the responses of rice varieties to different moisture levels should be assessed.

So it is high time to put concentration on the minimum usage of irrigation water to attain optimum crop production by efficient water management practices. Recently different types of indigenous organic amendments viz. rice straw compost (RSC), mustard meal (MM) and trichocompost (TC) have been considered for the experimental purposes. These amendments are ready source of basic nutrients for rice. These are relatively cheap but a high value nutrient rich bio-fertilizer and can be applied easily in the field. Thus, the present study was undertaken to evaluate the effects of different moisture levels and indigenous organic amendments on the growth, yield and yield contributing characters of rice.

Materials and Methods

A field experiment was carried out at Chandipur, Keraniganj (23°40´N, 90°18´E), Dhaka, Bangladesh during February to May (Boro season), 2018. The field was formerly cultivated with grass pea (*Lathyrus sativus)* at the early period of Rabi season. The soil belongs to Tejgaon soil series having pH value of 5.3, 0.05% of total N, 0.002% of available P and 0.01% of available K.

Three rice varieties such as BR 3, Local BRRI dhan 29 and BRRI dhan 74 were used for this study. Forty-two days old seedlings of all those varieties were planted. The maturation periods of aforementioned rice varieties were 170, 160 and 146 days, respectively. Three different indigenous organic amendments viz. rice straw compost (RSC), mustard meal (MM) and trichocompost (TC) were applied at the rates of 0, 4 and 8 t/ha; 0, 3 and 6 t/ha and 0, 2.5 and 5 t/ha, respectively, under the assignment of moist (70% soil moisture) and saturated (> 100% soil moisture) soil conditions (Table 1). Rice straw compost and mustard meal were collected from BRRI and trichocompost was collected from BARI, Gazipur.

The experiment was laid out in a split plot design with three replications, where two of the main plots were assigned for moist and saturated soil conditions, respectively. In each main plot, different rates of RSC, MM, and TC and three rice varieties were used in the sub plots as per treatment i.e. each main plot was composed of seven sub plots (2 m × 2 m). Each sub plot (experimental unit) consisted of 6 rows of plants. The seedlings were transplanted at the rate of two seedlings per hill with a spacing of 20 × 25 cm. The first and last rows were used as guard rows and the others were accounted for plant growth. The treatment denotation and their combinations used for the experiment are presented in the Table 1.

Table 1. Denotation and combination of the treatments used in the field experiment.

Treatment		Arrangement of the treatments	
No.	Denotation	Soil moisture level	Organic amendment (rate t/ha)
T_1	Control	Saturated condition (about 2-3 cm standing water was maintained)	Control soil
T_2	RSC_4ML_{100}		Rice straw compost at 4
T_3	RSC_8ML_{100}		Rice straw compost at 8
T_4	MM_3ML_{100}		Mustard meal at 3
T_5	MM_6ML_{100}		Mustard meal at 6
T_6	$TC_{2.5}ML_{100}$		Trichocompost at 2.5
T_7	TC_5ML_{100}		Trichocompost at 5
T_8	$RSC_0MM_0TC_0ML_{70}$	Moist condition (70% soil moisture was maintained)	Control soil
T_9	RSC_4ML_{70}		Rice straw compost at 4
T_{10}	RSC_8ML_{70}		Rice straw compost at 8
T_{11}	RSC_3ML_{70}		Mustard meal at 3
T_{12}	RSC_6ML_{70}		Mustard meal at 6
T_{13}	$RSC^{2.5}ML_{70}$		Trichocompost at 2.5
T_{14}	RSC_5ML_{70}		Trichocompost at 5

Two different soil moisture levels such as moist (70% soil moisture) and saturated (> 100% soil moisture) conditions were practiced from 30 days after transplantation of seedlings and continued until maturity of rice plants by adding required amount of irrigation water. Required amount of water for 100% soil moisture was multiplied by 0.7 to maintain 70% of soil moisture level. In case of saturated condition, more than 100% of irrigation water was applied with about 2-3 cm of standing water at experimental plots, whereas moist condition was maintained through intermittent control of irrigation water. The field moisture content of the plots was monitored through the measurement of gravimetric water content.

Particle size distribution of the initial soil was determined by Hydrometer method(6), soil pH by glass electrode pH meter(7), EC by USSL method(8) and CEC by CH_3COONH_4 extraction method(7). Organic matter content was determined by wet oxidation method(9) and total N by micro-Kjeldahl method(7). For the determination of available N content by 10% NaCl extraction method(7), for available P by Bray No. 1 extraction method(10) and for available S by $BaCl_2$ turbidity method(11) were used. Available cations *viz.* Na^+, K^+, Ca^{2+} and Mg^{2+} were extracted with 1 M CH_3COONH_4 (pH 7.0) followed by measurement of Na^+ and K^+ by flame photometer, and Ca^{2+} and Mg^{2+} by atomic absorption spectrophotometer(7). The properties of the studied soil are presented in Table 2. Total N of the indigenous organic amendments was determined by Kjeldahl method(12) and total P by colorimetric method(7). The properties of the used organic amendments are illustrated in Table 3.

Table 2. Physico-chemical characteristics of initial soil (0 - 15 cm).

Properties	Values
Textural class	Clay loam
Soil reaction (pH)	5.55
Electrical conductivity (µS/cm)	56.9
Organic carbon (%)	0.43
Cation exchange capacity (cmol/kg)	32.0
Total N (%)	0.16
Available NH_4^+ (mg/kg)	11.0
Available NO_3^- (mg/kg)	52.0
Available P (mg/kg)	3.00
Available S (mg/kg)	58.57
Available Na (cmol/kg)	1.14
Available K (cmol/kg)	0.28
Available Ca (cmol/kg)	2.98
Available Mg (cmol/kg)	1.47

Table 3. Composition and nutrient contents of organic amendments.

Organic amendments	Composition	Nutrient contents			
		N (%)	P (%)	K (%)	S (%)
Rice straw compost	Decomposed straw or husk of rice	1.05	0.10	1.50	-
Mustard meal	By-product of mustard oil seed crop	5.20	0.79	1.00	-
Trichocompost	Spore suspension of a *Trichoderma harzianum* + processed raw material (cow dung + poultry refuse + water hyacinth + vegetable waste + saw dust + maize bran + molasses)	2.42	1.26	1.42	0.41

In each subplot, two rows were randomly selected and tagged within the sampling area. Selected tillers from those rows were collected at 1.0 cm above the ground level during the maturity of crops of maturity at 110 days after transplantation to record tiller number, grain yield, No. of filled grains, No. of fissured grains and 1000-grain weight of rice crop.

Analysis of variance (ANOVA) and Tukey's Range Tests were done where necessary for interpretation of the data.

Results and Discussion

The effect of moist and saturated soil conditions on the number of productive tillers per hill was found significant ($p \leq 0.05$) along with the increased rates of RSC, MM and TC (Fig. 1). The tiller number of rice plants was counted at their maturity and found superior in both moist and saturated conditions. At saturated condition, the maximum number of tillers noting 22, 28 and 26 per hill for BR 3, BRRI dhan 29 and BRRI dhan 74, respectively, in RSC at 4 t/ha (T_2) succeeded by RSC at 8 t/ha (T_3), while moist condition exerted almost similar effects on tillers reporting 22, 28, 24 per hill in BR 3, BBRI dhan 29 and BRRI dhan 74, respectively in TC at 2.5 t/ha (T_{13}) and RSC at 4 t/ha (T_9). The magnitude of these effects was also augmented for rest of the amendments over T_8 treatment, which endorsed the least number of tillers (11/hill) because of practicing moist condition without any organic amendments (Fig. 1). The moist condition did not significantly affect the tiller number as compared to saturated condition. The results are consistent with the previous results stated by researchers[13] that moisture stress at the

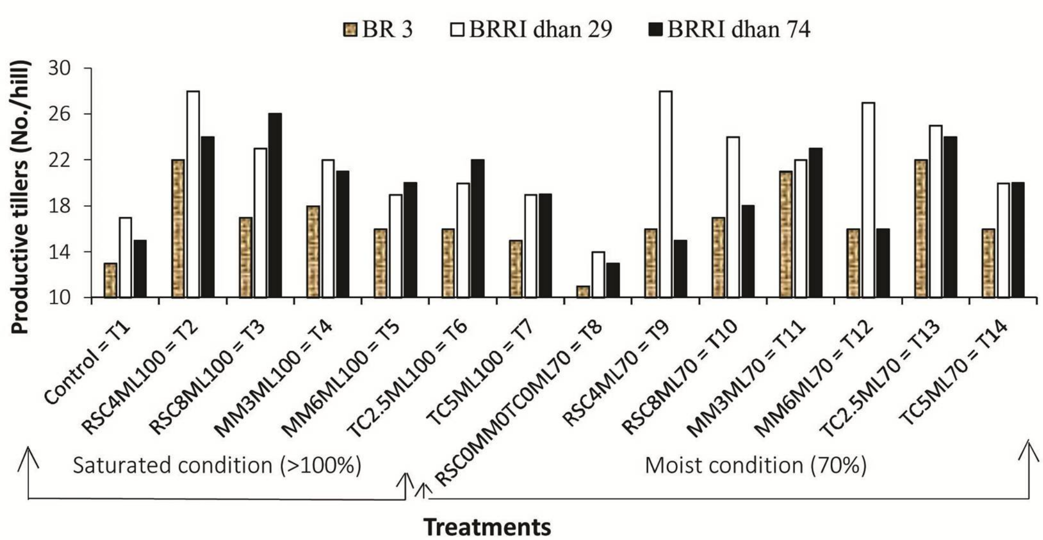

Fig. 1. Number of productive tillers per hill of BR 3, BRRI dhan 29 and BRRI dhan 74 grown in different moisture levels along with the imposition of different dosages of organic amendments.

flowering and ripening stages did not significantly affect the tiller number. Similar results were also reported by prior workers[14]. They revealed that increase in productive tillers might be due to application of organic amendments because of its better flow of various macro and micro nutrients along with plant growth substances into the plant system from the organic amendments.

Interactions between different levels of moisture and organic amendments were found to have positively significant ($p \leq 0.05$) effect on the grain yield of respective rice varieties. The grain yield was increased comprehensively with increased rates of RSC, MM and TC. The maximum grain yield of 8.71 t/ha was recorded for BRRI dhan 29 by RSC_4ML_{100} (T_2) followed by 7.90 t/ha for BRRI dhan 74 by RSC_8ML_{100} (T_3) and 7.70 t/ha for BR 3 by $TC_{2.5}ML_{70}$ (T_{13}) treatments. The minimum yield (3.42 t/ha) was recorded at $RSC_0MM_0TC_0ML_{70}$ (T_8) in BRRI dhan 74 as expected, where moist condition was practiced without any organic amendments (Table 4). Quite similar and significantly ($p \leq 0.05$) positive effects on grain yield were recorded for all rice varieties such as BR 3, BRRI dhan 29 and BRRI dhan 74. Almost analogous observations have been made by prior scientists(15) reporting that the grain yield increased with the application of rice straw compost due to an overall improvement in the chemical and biological properties of soil. A resembling finding was achieved by the researchers (14) in case of the application of TC on *Gladiolus grandifloras* L. The grain yield of rice was quite analogous under the moist and saturated soil conditions. Almost collateral and satisfactory yield was notified while assigning 70% field moisture in experimental plots as compared to >100% field moisture. These findings are in conformity with the findings of previous researchers(16,17). They stated that imposition of moist condition reduced water applied to the field by about 40 - 70% compared with saturated condition without a significant yield loss.

Saturated soil condition (> 100% moisture) exerted the maximum number of filled grains which were 124/panicle for BRRI dhan 29 by RSC at 4 t/ha (T_3), 117/ panicle for BRRI dhan 74 by MM at 3 t/ha (T_4) and 94/ panicle for BR 3 by RSC at 2 t/ha (T_2) treatments (Table 4). Meanwhile, the moist condition contributed almost closer and significantly ($p \leq 0.05$) positive effects on filled grains reporting 122, 115 and 92 per panicle for BRRI dhan 29, BBRI dhan 74 and BR 3 by TC at 2.5 t/ha (T_{13}), MM at 6 t/ha (T_{12}) and RSC at 8 t/ha ((T_{10}) over T_8 treatment, where the minimum number of filled grains was noted (Table 4). The number of filled grains assigning with 70% moisture was almost similar to >100% soil moisture. This might be attained due to the usage of different kinds of indigenous organic amendments. These amendments might boost up the translocation of assimilates to the rice grain. The present results are partially agreed with the findings of other researchers(16).

A synergistic interaction was found among the different doses of organic amendments, 70 and >100% field moisture on the number of fissured grains. The number of fissured grains was reduced with increased rates of organic amendments and the effects were more pronounced under the maintenance of 70% field moisture rather than 100% (Table 4). The least number of fissured grains was notified as 12, 14 and 17 per panicle for BR 3, BRRI dhan 29 and BRRI dhan 74 by the $TC_{2.5}ML_{70}$ (T_{13}), $TC_{2.5}WL_{100}$ (T_6)

and TC_5WL_{70} (T_{14}) treatments, respectively, whereas the highest grains (48/panicle) were recorded in T_8 treatment, where no amendments were applied except 70% field moisture (Table 4). The number of fissured grains per panicle was maximum in BRRI dhan 74 followed by BRRI dhan 29 and the minimum in BR 3. The application of organic amendments might play a pivotal role to reduce the number of fissured grain by securing sufficient assimilates production and its distribution to grains by avoiding the deposition of organic matter under low moisture input of 70% as compared to saturated condition (> 100%).

Table 4. Effects of soil moisture levels on the grain yield (t/ha), filled grains (No./panicle) and fissured grains (No./panicle) of three rice varieties incorporated with different rates of RSC, MM and TC under field condition.

Soil moisture level	Treat-ment No.	Grain yield (t/ha)			Filled grains (No./panicle)			Fissured grains (No./panicle)		
		BR 3	BRRI dhan 29	BRRI dhan 74	BR 3	BRRI dhan 29	BRRI dhan 74	BR 3	BRRI dhan 29	BRRI dhan 74
Saturated condition (> 100% soil moisture)	T_1	4.81 g	4.40 j	4.52 j	77 de	69 gh	68 gh	34 ab	41 a	43 a
	T_2	6.69 c	8.71 a	7.04 b	94 a	100 d	110 b	24 ef	30 bc	32 bc
	T_3	4.35 j	5.85 f	7.90 a	82 cd	124 a	100 cd	30 bcd	26 cd	29 bcde
	T_4	6.49 d	5.89 f	5.70 f	85 bc	81 f	117 a	33 abc	35 b	34 b
	T_5	6.09 e	4.78 i	5.30 g	73 e	56 i	66 h	18 ghi	19 efgh	27 cde
	T_6	6.06 e	5.44 g	6.93 c	40 i	73 g	104 c	30 bcd	14 h	26 de
	T_7	5.64 f	5.04 h	6.03 e	46 h	93 e	88 e	28 cde	24 de	20 fg
Moist condition (70% soil moisture)	T_8	4.17 k	4.30 k	3.42 k	57 g	45 j	56 i	36 a	45 a	48 a
	T_9	5.59 f	8.58 b	5.04 h	81 cd	65 h	95 d	23 efg	17 gh	24 ef
	T_{10}	4.70 h	6.21 e	5.06 h	92 b	113 c	72 g	26 def	21 defg	28 cde
	T_{11}	6.99 b	6.19 e	6.93 c	89 ab	71 g	104 c	17 hij	25 cd	31 bcd
	T_{12}	4.65 h	7.00 c	4.60 i	79 d	79 f	115 b	15 ij	18 fgh	28 cde
	T_{13}	7.70 a	6.32 d	7.02 b	63 f	122 b	80 f	12 j	17 gh	29 bcde
	T_{14}	4.56 i	5.40 g	6.31 d	79 d	59 i	67 gh	22 fgh	23 def	17 g

In a column, figures with same letter(s) do not differ significantly whereas figures with dissimilar letter differ significantly as per Tukey's Range Test at 5% level of probability.

The ANOVA and Tukey's Range Test showed that 1000-grain weight of rice significantly ($p \leq 0.05$) enhanced with the higher rates of RSC, MM and TC alone or in combination with 70% and 100% field moisture levels. The highest grain weight of 38.3 g was noted by the RSC_4ML_{70} (T_9) treatment for BRRI dhan 74, 34.3 g by the TC_5ML_{100} (T_7) for BRRI dhan 29 and 36.5 g by the RSC_4ML_{70} (T_9) treatment for BR 3, whereas the lowest grain weight (20.0 g) was attained in T_8 treatment (Table 5). Almost similar and closer grain weight of rice was notified for both 70 and 100% field moisture along with different rates of organic amendments. These results are quite similar with the findings of previous workers(13,16,18). They revealed that less amount of water input at the flowering and ripening stages did not significantly affect the 1000-grain weight and thereby did not affect rice production.

Table 5. Comparison of 1000-grain weight and harvest index of BR 3, BRRI dhan 29 and BRRI dhan 74 as influenced by different soil moisture levels and organic amendments.

Soil moisture level	Treat-ment No.	1000-grain weight			Harvest index		
		BR 3	BRRI dhan 29	BRRI dhan 74	BR 3	BRRI dhan 29	BRRI dhan 74
Saturated condition (> 100% soil moisture)	T_1	22.4 l	21.1 g	21.9 k	0.43 cd	0.45 bc	0.46 gh
	T_2	33.3 c	32.1 b	32.7 d	0.62 ab	0.58 a	0.70 a
	T_3	28.8 fg	21.4 g	38.0 a	0.45 c	0.46 bc	0.57 de
	T_4	28.6 g	24.9 e	22.6 ij	0.62 ab	0.56 a	0.54 ef
	T_5	29.5 e	28.6 c	28.9 f	0.60 b	0.50 b	0.50 fg
	T_6	31.0 d	28.8 c	23.3 gh	0.67 a	0.59 a	0.64 bc
	T_7	26.8 i	34.3 a	22.5 j	0.59 b	0.56 a	0.60 cd
Moist condition (70% soil moisture)	T_8	20.5 l	20.4 h	20.0 l	0.39 d	0.43 c	0.44 h
	T_9	36.5 a	32.4 b	38.3 a	0.59 b	0.61 a	0.48 gh
	T_{10}	29.2 ef	24.8 e	34.0 c	0.44 cd	0.48 bc	0.48 gh
	T_{11}	34.3 b	28.8 c	31.6 e	0.67 a	0.46 bc	0.55 def
	T_{12}	24.4 k	27.0 d	23.8 g	0.47 c	0.47 bc	0.45 gh
	T_{13}	26.0 j	23.1 f	23.1 hi	0.59 b	0.59 a	0.67 ab
	T_{14}	27.5 h	28.4 c	35.9 b	0.58 b	0.57 a	0.54 ef

Harvest index as determined showed positively significant ($p \leq 0.05$) interaction effects of soil moisture levels and organic amendments on rice varieties (Table 5). All of the treatments are arranged in order of harvest index regardless of rice varieties and the sequence is:

RSC_4WL_{100} (T_2) = $TC_{2.5}WL_{100}$ (T_6) > $TC_{2.5}WL_{70}$ (T_{13}) > TC_5WL_{100} (T_7) > MM_3WL_{100} (T_4) > RSC_4WL_{70} (T_8) = MM_6WL_{70} (T_{11}) = TC_5WL_{70} (T_{14}) > $MM_{12}WL_{100}$ (T_5) > RSC_8WL_{100} (T_3) > RSC_8WL_{70} (T_{10}) > MM_6WL_{70} (T_{12}) > WL_{100} + no amendment (T_1) > WL_{70} + no amendment (T_8)

From the above results it can be concluded that the low moisture input of 70% along with organic amendments of RSC, MM and TC can significantly increase rice yield. Among the amendments used, RSC at 4 t/ha ranked first in order of rice yield followed by the MM at 6 t/ha and TC at 5 t/ha alongside the imposition of 70% field moisture rather than 100%. Hence, it can be concluded that low water input practice would be effective and might save huge amount of fresh water, the present day need of climate change.

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